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SAWMILL CONVERSION EFFICIENCY AND WOOD RECOVERY OF TIMBER SPECIES IN CROSS RIVER STATE NIGERIA

SUMMARY

Wood wastage during conversion has been identified as one of the factors contributing to forest loss. This study analysed efficiency of timber conversion at the sawmill section of Calabar Wood Export Processing Factory (CWEPF), Cross River State, Nigeria. Ten commonly processed timber species were monitored through the various machines during the conversion process. The various wastes associated with the conversion and numbers of sawn timber produced were analysed. The mean percentage of total wood waste generated during conversion process at the mill was found to vary from 46.89% in *Cylicodiscus gabunensis* to 55.49% in *Tectonia grandis*. The mean volume of wood waste due to back was found to vary from 0.019m^3 in *Cylicodiscus gabunensis to* 0.133m^3 in *Afzelia africana*. The mean percentage of recovery efficiency for the ten sampled log species was 46.87%. The recovery percentage varied from 46.24% in *Afzelia Africana* to 53.11% in *Cylicodiscus gabunensis.* The percentage of recovery of the ten sampled species was found to be significantly different. The study shows that conversion efficiency of the mill is comparably low; this has the potential of increasing demand for more logs and forest exploitation. There is need for improved technology that promotes efficient and effective timber conversion to facilitate sustainable timber exploitation in the state.

Keywords: Lumber recovery, conversion efficiency, sawmill, round log, wood waste

INTRODUCTION

The sawmill industry in Nigeria was among the most developed sectors of the nation's economy in the 1960's to the early 1970's contributing about 70% of the country's Gross Domestic Product (GDP) (Ogunwusi, 2012). Sawmills were discovered to be a major contributor to rural development in most communities where they exist. The reason for this is that the presence of sawmill also facilitates establishment of small scale enterprises such as furniture industries, timber merchants, local transport, among others (Bennett, 1974; Akachuku, 1998; 2000).

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However in recent years, sawmills in Nigeria are undergoing a difficult period as a result of a multiplicity of factors (Ogunwusi, 2012). Most sawmills are depreciated, have low recovery rate of less than 53% and lacks the capacity to process small diameter logs from forest plantations (FOSA, 2009). Low recovery rate as well as lack of capacity to process small diameter logs from tree plantations by sawmills have been discovered as significant drivers of deforestation and forest degradation in Nigeria (Ogunwusi, 2012; FASO, 2009). Timber supply to sawmill in the country is mostly limited to few forest reserves where the terrain is rough (Adeyoju, 2001). This trend is having negative impact on profitability of most sawmills in Nigeria. In the same vein, Oriola (2009) reported a decline in the performance of sawmills in Nigeria. This disturbing paradigm is slowing down the development of forest industries in the country.

Adeyoju (2001) observed that the country's total forest estate, which stood at 20% of total land area in the 1970s', has shrunk to 7%. Uneke (2008) has estimated the annual deforestation rate in Nigeria to be 3,984 sq.km per annum. In addition, it was estimated that the country lost about 55.7% of its primary forests between 2000 and 2005 (Uneke, 2008). A re-think of forest resource utilization and management is therefore required in Nigeria with a new innovative way of improving efficiency of timber utilization, especially in sawmills.

Badejo and Giwa (1985) reported that timber recovery factor is an indication of the efficiency of how sawmills are run. However, the impact of factors such as log size, length, quality or grade, saw kerf width, and decision making by sawmill personnel in enhancing or reducing efficiency of sawmill conversion has not been investigated.

The forest area of Cross River State has been discovered to constitute about 90% of Nigeria's remaining primary rainforest (FAO, 2000; Kehinde & Awoyemi, 2009). However, the forests has been decreasing at alarming rate. There is therefore a need for efficient use of harvested logs from the forest estate by sawmill in the state to reduce the rate of deforestation. Calabar Wood Export Processing Factory (CWEPF) is the largest integrated forest product industry in Cross River State. Sawmill conversion efficiency in CWEPF is analysed in terms of timber recovery efficiency which is a ratio of the volume of sawn timber (output) to volume of round (log input). From the results of this study, it is envisaged that recommendations aim at promoting efficient processing of timber in sawmills for sustainable forest exploitation will be made.

MATERIAL AND METHODS

Study area

This study was carried out at the sawmill section of Calabar Woods Export Processing Factory (CWEPF). CWEPF is an integrated forest industry and is situated in Calabar; the capital of Cross River State located in coastal south-eastern part of Nigeria. Round log supply to sawmill in Nigeria is mostly from the few remaining tropical moist forest, and about 90% of Nigeria's remaining primary rainforests are located in Cross River State (FAO, 2000). CWEPF has three different sections including sawmill section; veneer/plywood section; and furniture and joinery section. The sawmill utilizes about 18,000m^3 of round log annually. Round log supply to the mill is mostly from its logging concession from Cross River State Forestry Commission at Mbarako in Akampka local government which supplies about 12,000m^3 annually. The mill also buys round logs (about 6000m^3 per annum) from individual forest owners in the area.

Data Collection Procedure

Data collection started with sampling of 100 round logs from the log yard of CWEPF. Ten logs of timber species commonly processed at the mill (Table 1) were selected for the study. The total number of round logs used in this study fall within the recommendation made by David (1986) in his work on sawmill improvement programme in United States of America (USA) where he recommended the sampling of 100 to 300 logs in analysing sawmill conversion efficiency. Ten log samples from each of the ten indigenous timber species commonly processed in the mill were collected in order to determine the volume of round logs being utilized at the mill.

The measurements of the logs taken before conversion included the length, back thickness, the over back diameter at both basal area and top cross sectional, and under back diameter at both basal girth and top girth. After conversion the total number of sawn timber generated from each round log was also counted and their dimensions measured. The recorded measurements were then used to estimate the back volume, over back volume and under back volume of the logs as well as the volume of sawn timber produced by applying appropriate formulas.

Table 1: Commonly processed timber species in Calabar Woods Export Processing Factory (CWEPF), Cross River State, Nigeria

S/N	Common Name	Scientific Name
1	African Oak	*Afzelia Africana*
2	African Padauk	*Pterocarpus soyauxii*
3	Teak	*Tectonia grandis*
4	Akpupaja; Erukoya	*Diospyros suaveolens*
5	Nigerian mahogany	*Khaya ivorensis*
6	Okan; African greenheart	*Cylicodiscus gabunensis*
7	Red ironwood	*Lophira alata*
8	Gmelina	*Gmelina arborea*
9	Iroko; African Teak	*Milicia excelsa*
10	Bokyi; Achi	*Brachystegia eurycoma*

Determination of log volume

The volume of round log (both volume over back and volume under back) was calculated using the Smalian formula. This formula was used because it takes into consideration the severity of taper of the logs. The formula is given thus:

$$V = \frac{(Au+Ab)L}{2} \quad (1)$$

Where: Au = Cross sectional area of the upper part of the log; Ab = Basal area of the log; L = Length of the log;

Au, Ab were calculated using the formula:

$$A = \frac{D^2\pi}{4} \quad (2)$$

Where: A = cross sectional area of the log; π = 3.14; D = Diameter of the Log.

Determination of back volume of logs processed

The total volume of waste due back was calculated by subtracting volume under back from volume over back. Thus back volume is:

$$Vback = Vou – Vod \quad (3)$$

Where: Vback = Back volume; Vou = Volume over back; Vod = Volume under back.

Determination of volume of processed lumber

The major end products from sawmill are wood floorings. Common sizes of wood flooring produced in the sawmill are: 27mm x 67mm x 320mm; 27mm x 55mm x 640mm; 80mm x 80mm x 620mm; and 27mm x 140mm x 950mm.

The volume of sawn lumber produced at the mill was determined using the formula:

$$VL = N \times L \times B \times H \quad (4)$$

Where: VL = volume of sawn lumber; N = number of sawn lumber; L = Length of sawn lumber; B = Breadth of sawn lumber; H = Height/thickness of sawn lumber.

Determination of volume of total wood waste

The total volume of waste generated in the mill was calculated by using the formula:

$$Vw = Vt – Vp \quad (5)$$

Where: Vw = volume of wood waste; Vt = volume of round log prior to processing (Volume over back); Vp = volume of produced sawn lumber (extracted from the log).

Determination of lumber conversion efficiency

Conversion efficiency in this study was estimated as a ratio of input to output.

RESULTS AND DISCUSSION

Mean volume of round log, sawn lumber and wood waste

The standard length of the round logs being processed at the mill is 3.6m. The mean volume of round log, back, sawn lumber, wood waste, and percentage of recovery of the ten sampled species is presented in Table 2. The mean of the over back volume of round log being utilized at the mill vary from 0.883m^3 in *Cylicodiscus gabunensis* to 1.315m^3 in *Brachystegia eurycoma*. Also the back thickness of the logs being utilized at the mill varied from 2mm to 7mm; this was within the range of 1mm to 3mm reported by Wiant et al. (1996) for back thickness of tropical trees. The one sample statistic test (t-test) as presented in Table 3 shows that there was a significant difference (p=0.000; t=59.744; mean=46.9) for the percentage of recovery of the ten sampled log species.

Table 2: Mean volume of round log, sawn lumber and associated wood wastes

Name of Log	Volume over back (m^3)	Volume under back (m^3)	Volume of back (m^3)	Volume of sawn log (m^3)	Total waste volume (m^3)	% Recovery	% Volume of total wood waste
Afzelia africana	1.198	1.065	0.133	0.554	0.644	46.244	53.756
Brachystegia eurycoma	1.315	1.290	0.025	0.611	0.704	46.464	53.536
Cylicodiscus gabunensis	0.883	0.864	0.019	0.469	0.414	53.114	46.886
Diospyros suaveolens	1.180	1.154	0.026	0.555	0.625	47.034	52.966
Gmelina arborea	1.006	0.978	0.028	0.449	0.557	44.632	55.368
Lophira alata	1.086	1.045	0.041	0.503	0.583	46.317	53.683
Khaya ivorensis	1.262	1.229	0.033	0.604	0.658	47.861	52.139
Milicia excelsa	1.188	1.156	0.032	0.568	0.620	47.811	52.189
Pterocarpus soyauxii	1.080	1.052	0.028	0.487	0.593	45.093	54.907
Tectonia grandis	1.065	1.039	0.026	0.474	0.591	44.507	55.493

Efficiency of log conversion in the sawmills

Conversion ratio in the mill varied from 44.5% to 53.1%. The highest mean conversion ratio (53.1%) was observed in the sawing of smooth round log of *Cylicodiscus gabunensis*. Mean conversion ratio was as low as 44.51% in *Tectonia grandis*. Many factors were observed to have influence on conversion efficiency in the mill, this include inherent defects in the timber, severity of taper, and sharpness of saw. The common defects in sawn timber include knots, woodborer galleries, gum veins and rot.

Table 3: One sample t-test for percentage of recovery for ten sampled log species

Parameter	N	Df	Mean	t-value	Sig. (2-tail)	Std. Deviation	Std. Error	95% Confidence Interval of the difference	
								Lower	Upper
Values	10	9	46.9	59.7	0.00	2.48	0.78	45.13	48.68

DISCUSSION

The overall average, conversion ratio of the mill at CWEPF is 46.9%. Although the efficient of the mill was within the range of 42% to 60% for tropical hard woods as reported by Byers (1960); however, it is lower than the average timber recovery of 53.69% observed by Egbewole et al. (2011) for selected sawmills in the south western states of Nigeria. Gyimah and Adu (2009) have also reported a higher recovery percentage of 54.5% for sawmills in Malaysia, and recovery percentage of 60% - 70% for sawmills in Venezuela. More so the fact that the percentage of recovery of the ten sampled log species differs significantly shows that with introduction of proper intervention measures, conversion efficiency in the mill can be significantly improved. Attainment of high level of sawmill conversion efficiency will therefore inevitably significantly reduce the rate of timber exploitation in the state and the country at large.

The results from this study has shed light on efficiency of timber recovery in CWEPF’s sawmill which is the largest integrated forest industry in Cross River State. The average of 46.9% timber recovery efficiency calculated as the output of the mill needed to be improved. If log conversion is improved upon, these have the potential of promoting efficient timber utilization and reduce the rate of timber exploitation in the state. In support of this, Kehinde and Awoyemi (2009) opined that efficient timber utilization, particularly in sawmills, will be a significant factor in reducing the fast rate of diminishing quantity of merchantable timber and degradation in Nigerian forests.

The current rate of wood waste resulting from inefficient log conversion technology in forestry sector of Nigeria calls for concern. Low level of log conversion will lead to low volume of final wood produced, hence increase in forest exploitation as a result of increase in demand for more logs. Given the fact that timber exploitation in Nigeria is mostly from the few remaining tropical forests in the country, an understanding of the efficiency of timber utilization in sawmills is very crucial. CWEPF’s sawmill processes about 15,986 round logs annually and an average of 44 round logs per day; the mill is undeniably a significant driver of logging in the state. Sawmill conversion efficiency is therefore central and relevant in achieving sustainable timber supply and forest management in Nigeria.

Green economy has been defined as improvement in human well-being and social equity while significantly reducing environmental risks and ecological scarcities (UNEP, 2011). This innovative interventions of efficient timber recovery is needed to facilitate transition to green economy in the forestry sector. This is to make the sector active in Nigeria's effort geared towards attaining sustainable management of its forest estate as well as mitigating the impacts of climate change. Urgent efforts to promote high timber recovery efficiency in sawmill and encourage efficient timber utilization with the view of positioning the country's forestry sector in transition to green economy is therefore essential.

It is no doubt that improved efficiency of timber recovery in sawmills will enable the Nigerian forest sector to play active role in Nigeria's quest for attainment of sustainable development. At the operational level, this will reposition the country forest industry to actively contribute to reduction of carbon emission; improved timber resource utilization efficiency; and prevent loss of biodiversity and ecosystem services.

CONCLUSIONS

Sawmill conversion efficiencies are important for maintaining sustained timber supply and forest management. Given the high volume of wood waste generated during sawmill conversion process; new and innovative method of profitable wood waste utilization should be developed and supported by the concerned authorities and stakeholders. To attain this waste reduction, there is need for replacement of the low efficient and high waste generating wood processing machineries in the mills in the study area. Due to the high cost involved in procuring standard wood processing machineries, government and financial institutions should assist sawmill owners by providing financial assistance or low interest loan. This will be an indirect cost for reducing forest exploitation. There is also the need for research and studies that will develop strategies to enhance sawmill conversion efficiency. To encourage this, there should be provision of appropriate research funding and other supports. Finally, periodic assessment of sawmill conversion efficiency in Nigeria should be done in order to facilitate formulation of policies that will lead to rejuvenation of the Nigerian forestry sector.

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EFIKASNOST KONVERZIJE DRVETA NA PILANII OPORAVAK DRVNIH VRSTA U DRŽAVI KROS RIVER U NIGERIJI

SAŽETAK

Velika količina drvnog otpada tokom konverzije je jedan od faktora koji doprinose gubitku šuma. Stoga, ova studija analizira efikasnost konverzije drveta u sektoru pilane u fabrici za preradu i izvoz drveta u gradu Kalabar (CVEPF), u državi Kros River, u Nigeriji. Posmatrana je obrada različitim mašinama deset najčešće obrađivanih vrsta drveta tokom procesa konverzije. Analziran je otpad koji nastaje konverzijom i prizvedena rezana građa. Utvrđeno je da prosječna vrijednost ukupnog drvnog otpada generisanog tokom procesa konverzije u pilani varira od 46.89% kod *Cylicodiscus gabunensisdo* 55.49% kod *Tectonia grandis*. Utvrđeno je da prosječna zapremina drvnog otpada zbog starosti varira od 0.019m^3 kod *Cylicodiscus gabunensis* do 00.133m^3 kod *Afzelia africana*. Prosječna vrijednost efikasnosti oporavak deset uzorkovanih vrsta iznosila je 46.87%. Utvrđeno je da se procenat oporavka značajno razlikuje kod deset uzorkovanih vrsta. Studija pokazuje da je efikasnost konverzije na pilani niska, što otvara mogućnost povećanja potražnje i održiviju eksploataciju šuma. Postoji potreba za savremenijom tehnologijom, koja promoviše efikasnu i efektivnu konverziju drveta, kako bi se obezbijedila održiva eksploatacija šuma u zemlji.

Ključne riječi: oporavak drvnih vrsta, efikasnost konverzije, pilana, balvan, drvni otpad